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Valuation of Market Uncertainties for Contaminated Land

Stephan Bartke *[a]

* Corresponding author

[a] Helmholtz Centre for Environmental Research – UFZ
Department of Economics and Department Groundwater Remediation
Permoserstr. 15 | 04318 Leipzig | Germany

Phone: +49 341 235 1683 | Fax: +49 341 235 451683 | stephan.bartke@ufz.de

Abstract

The revitalisation of contaminated land carries many risks and uncertainties. This paper aims to reveal drivers of risk perception and to introduce a novel valuation method for the assessment of market-perceived risks for sites polluted by earlier use in a transparent and comprehensible procedure. International approaches to account for value deductions due to contaminations and resulting uncertainties are reviewed. Based on the literature review and a national survey amongst German professional appraisers, a risk assessment methodology is elaborated, outlined and applied in a case study approach. We find that areas that have been properly decontaminated on average still have a depressed market value of 12.25%. Quantities such as location, time and feasibility of passing on risks can be combined in an algorithm to determine the absolute value reduction for a specific property to be appraised. Results should help appraisers, international investors and portfolio managers to deepen their understanding of valuation of risks associated with (previously) contaminated land.

Keywords

Real estate appraisal, Contaminated land, Valuation of perceived uncertainties, Stigma and marketability risk, Risk scoring method

1 INTRODUCTION

Potential investors are reluctant to reuse contaminated land due to the diversity of perceived risks. Occasionally they demand that all pollution should be removed from a site contrary to the statements of environmental experts that residual contamination of the site would by adequate for the intended future use. Considerable value diminutions for actual or potential contamination from previous use (soil or groundwater pollution, warfare agents, listed buildings etc.) severely impair the marketability of derelict land. These reductions depend not so much on the (level of) expected rehabilitation costs but rather on their uncertainty and remaining stigma effects. If such brownfields are to be merchantable and, particularly, contaminated properties reactivated, a transparent value appraisal for these uncertainties is vital.

Whereas in decision theory risk is defined as a state of complete probabilistic knowledge, in practice, the valuation of contaminated sites is characterised by heterogeneous sources of often incomplete information and thus only partial probabilistic knowledge, i.e. uncertainty. Contaminated sites are characterised by uncertainties influencing the assessment of remediation costs due to the variability in soil physics and the complexity of the contamination in the subsurface (Norrman, 2001, NRC, 2005). Behind this background, assessing the market value remains challenging as the remediation to meet specific cleanup goals might be incomplete and some pollution goes undetected due to inaccurate investigation modelling and technologies. Moreover, some substances in the ground may not be known as pollutants at the time of the investigation but are discovered later. Resultantly, market reluctance occurs due to perceived liability, insurability and marketability risks (Bartke, 2010).

Adams et al. (1985) and Beattie (1991) already found that the appraisal of contaminated land is one of the most vexed issues in the valuation of regeneration projects and that there are shortcomings in traditional valuation methodologies. Since the 1990s, a number of papers have dealt with the valuation of contaminated properties. At the same time, The European Group of Valuers' Associations (TEGoVA) has recognized the appraisal of contaminated land as a key subject for future research (Adair et al., 2001). As Weber et al. (2008) note, scientific processes need to be established for valuers. Nevertheless and despite acceptance of elements of a general valuation framework (cf. below USPAP, AO9), no generally accepted and practicable method has so far been found for evaluating market *uncertainties* for contaminated land.

In the following, the article introduces the relevant international valuation standards and gives a survey of expert valuation concepts proposed in the literature for sites polluted by previous use. As a next step, a synopsis of the main categories of uncertainties driving market perceived risks is provided. Based on a literature review and a poll of German professional appraisers, it is shown how determinants of value diminutions can be better understood and integrated into a simple valuation system for risk assessment in property valuation. The proposed method has been applied in a case study approach. Based on these results, final conclusions will be drawn.

2 VALUATION STANDARDS AND STATUS QUO

The concept of contaminated sites has no uniform definition in the various scientific disciplines and national environmental and soil protection laws (cf. Dasgupta and Tam, 2009). Following Hilse and Bischoff (2005), this paper refers to contamination in the sense of pollution due to previous use, including all characteristics of a property (built on or not) deriving from local use in the past and coming under the value-related scope of inter-/national environmental law and/or sections of other technical legislation pertaining to the environment.

The United States have a generally accepted framework for analyzing issues pertinent to the appraisal of contaminated sites that include definitions of contamination, property value diminution, environmental stigma and many others. They are laid down in the Appraisal Opinion (AO 9) by the Uniform Standards of Professional Appraisal Practice – USPAP (Appraisal Foundation, 2008) and discussed by Appraisal Institute (2008) and among others by Jackson (2003a, 2010). International guidelines for appraisers, i.e. norms set next to USPAP by the International Valuation Standards – IVS (IVSC, 2007), European Valuation Standards – EVS (TEGoVA, 2009) and the Royal Institute of Chartered Surveyors Valuation Standards (known as the Red Book) (RICS, 2008), touch the problem without specifying methods how to assess uncertainties influencing the marketers' behavior (cf. USPAP AO9, IVS GN7).

The basic procedure for the valuation of brownfields is a residual value approach where *expected* rehabilitation costs calculated by independent environmental experts are deducted from the value of a comparable uncontaminated site (Sheard, 1992) further taking into account use and risk effects (cf. USPAP AO 9). According to Chalmers and Jackson (1996) and Woestmann et al. (2011), the determination of environment-specific estimations and problems should be left to environmental engineers (costs) and attorneys (liabilities) separated from appraisal as such. However, in practise valuation reports do not pay enough attention to risks resulting from previous use, even though international appraisal standards invariably demand that all value-related information of a site should be considered when establishing market values.

Neglect for previous pollution in determining market values is due not only to a lack of market data for appraisal but often to terminological differences between appraisers and environmental specialists whose judgments are frequently based on disparate or even contradictory concepts. If not given concrete instructions, for example, environmental experts looking at *contamination* merely in terms of *hazard defence* as codified in the national soil protection laws will derive rehabilitation costs without allowing for intended use. Though in economic terms, the most probable highest and best use (EVS1 5.4.2., IVSC 2007, 28) should be assumed when determining market values.

In practice despite rising awareness amongst appraisers of new technologies of decontamination, a lack of environmental know-how among appraisers, missing market data and uncertain estimates for rehabilitation costs often prevent costing for cleanups and follow-up with a precision required to determine market values. As a result, (previous) contamination is often seen as a technicality (left aside or taken care of by special assumptions) or there are merely verbal qualifications or pure subjective increments (cf. Großmann et al., 2001, Kinnard et al., 2002, Chan, 2009 or Moser, 2009). Sometimes, appraisers apply a general non-specified lump-sum deduction for so-called stigma effects in order to take into account risks perceived by market participants.

A poll of German appraisers gave evidence that transparent and easy to use methods are missing to assess the value diminution due to perceived risks of contaminated sites.

3 LITERATURE REVIEW ON THE ASSESSMENT OF MARKATABILITY RISKS

The rehabilitation and reuse of contaminated land carries many risks that are influencing market participants' perceptions on what is the fair market value of such a site. Marketing risks have been studied in the United States since the 1980s, with Patchin (1988) being among the first to develop a framework for appraising contaminated sites. Apart from rehabilitation costs for hazard defence, his valuation concept includes possible litigation expenses, exemptions from liability, financing costs and stigma effects as adjusted risk premiums. Higher risk premiums, in this approach, reflect the difficult marketing conditions for contaminated areas. Patchin also points to the potentially lower marketability of a property after rehabilitation, the so-called stigma effect from a history of contamination. In another study, Patchin (1991) takes a closer look at the cost risks exceeding rehabilitation expense and detracting from the value of (suspected) contaminated sites. He points out that these perceived cost risks need not be rational in order to reduce value. He identifies several determinants that constitute stigmatization: a fear of more claims being made by the state or the public, unwillingness of market third parties to provide mortgages or other financing instruments, and a fear of hidden or underrated rehabilitation costs. These factors affect the market value and marketability prior to the complete rehabilitation and cause buyer resistance and value reduction, even thereafter. Compared with a greenfield site, an investor would have to carry extra burdens from the organization, execution and monitoring of rehabilitation work, which Patchin (1991) refers to as *trouble factors*.

Mundy (1992a) studies contradictions between actual risks and those perceived by marketers in relation to polluted sites. He depicts that value reductions of a (previously) contaminated property exceeding the difference between the value of a non-polluted site used for comparison and the actual rehabilitation costs, i.e. stigma, are directly related to the level of uncertainty and subjectively perceived risks of (former) contamination. In addition, this stigma effect depends on the scope of information on contamination and rehabilitation available to marketers, which eventually lessened stigma as rehabilitation proceeded.

Chalmers and Roehr (1993) take up Mundy's argument that risk premiums are related to information and outline the dependence on the progress of investigation and remediation. Similar to Patchin (1991), they emphasize that marketers propose markdowns from their perception of risks rather than the actual pollution load. Hence, the extent of risk awareness depends on the perception of changes (better physical condition of the property, cleanup completed) in the rehabilitation process (cf. McClelland et al., 1990 and Slovic et al., 1991), but also on positive or negative media reporting about progress made in reclamation (Siemens, 2003). Chalmers and Roehr (1993, 33) therefore define stigma as „the reduction in value caused by contamination resulting from the increased risk associated with the contaminated property". Syms (1997, 179) lists determinants of value reduction and defines stigma as "that part of any diminution in value attributable to the existence of land contamination, whether treated or not, which exceeds the costs attributable to a) the remediation of the subject property, b) the prevention of future contamination, c) any known penalties or civil liabilities, d) insurance, and e) future monitoring."

Several approaches have been proposed as methods of valuation appropriate to assess contaminated market value diminution. Jackson (2003b) presents a range of possible valuation techniques and methods (cf. also Tonin 2006, Simons and Sementelli 2006), including comparative purchase price analysis (cf. Patchin, 1994, Sym and Weber, 2003), multiple regression analysis which may be used to define the strength and significance of purchase price determining factors (cf. also Dotzour, 1997), or the surveying of market participants to collect and understand data which is important to the valuation as such (cf. also Greenberg and Huges, 1993 and McLean and Mundy, 1998a). In Jackson (2004a), the author also discusses analyses of *case studies*, emphasizing the need for using a variety of procedures for evaluation and for relying on market data where possible. Further methods for valuation were proposed such as option pricing methods (Lentz and Tse, 1995), mortgage-equity analysis (Chalmers and Jackson, 1996), adjusting all-risk-yield and by percent value reduction (Richards, 1997), Monte-Carlo-Simulation (Weber, 1997), a science-based integrated Triad approach (Weber et al., 2008) or fuzzy real options (Wang et al., 2009). Syms (1997) introduces a risk assessment model for the assessment of stigma attached to the past or present industrial use of a site. This risk assessment is based on the observed range of stigma by Patchin (1994) and adjusts this for a specific site by a scoring of the relevant professionally perceived riskiness out of 26 industrial activities, and, based on empirical research, for the perceived impacts on value before and after redevelopment as well as due to the chosen method of treatment. However, the methods proposed require extensive data collection and evaluation which, in practice, is often impossible due to time constraints and cost limitations.

A large number of empirical studies in the literature use market data to explore whether previous contamination has an effect on prices and, if this is the case, whether these effects are related to the remediation progress. Another aspect are the implications of the general market situation (real estate boom/slump) on these effects (for this and a detailed list of literature see Jackson, 2001a, 2002, Hurd, 2002, and Longo and Alberini, 2005). In contrast to residential properties, less real estate data is available for industrial sites that could be used for market price studies so that mostly individual cases have been analyzed in the past. Jackson (2001b), for example, conducts a metaanalysis of seven case studies and in each significant value reductions for industrial properties are found, as reflected in reduced marketability and less willingness to finance on the part of lenders, however, the author found no evidence of post-remediation stigma. The literature on detrimental conditions affecting industrial properties in general supports the view that stigma effects are temporary and values recover following remediation (Jackson, 2009).

In the last decade, controversial discussions increasingly focused on enhancing the appraisers' capabilities to assess marketability risks through methodologies such as sample surveys and market interviews (e.g. Jackson, 2004b) or approaches of stated preferences, such as contingent valuation (e.g. McLean and Mundy, 1998b, Wilson 2006, Frey and Roddewig, 2006). In general, these methods are helpful for providing background to understanding the possible impacts of contamination, but typically they are not seen as methods to determining actual market behavior and market values, which should be based on data of actual transactions (cf. Jackson, 2003b) – whenever available. Nevertheless, a growing literature is using these techniques to broaden the understanding of determinants and assess marketability risks.

Table 1 summarizes a number of studies into the effects of risks related to pollution from previous use on the market value of (formerly) contaminated sites.

Table 1: Survey of exemplary empirical studies on the assessment of marketability risks of (formerly) contaminated sites

Study	**Type of real estate**	**Observed impact**	**Method**
Gamble / Dawning 1982	Resi-dential	Temporarily reduced marketability of properties in neighbourhood of nuclear power plants	Multiple regression analysis
Kohlhase 1991, Thayer et al. 1992, Reichert et al. 1992	Resi-dential	Depressed sales prices of properties bordering on a (potentially) contaminated site; sales prices of neighbouring properties rise with distance from contaminated site	Hedonic price model
Page / Rabinowitz 1993	Industrial	Significant effect of risks from contaminated sites on sales prices	Case studies
Patchin 1994	Industrial	Stigma causes loss in value from 20.9 – 69% and more if demand is low [a]	Case studies
Simons / Sementelli 1997	Industrial	Less financeability and 50% less market sales for contaminated vs. uncontaminated sites	Sales price collection
Guntermann 1995	Industrial	Neighbourhood effect from open landfill, prices of adjacent industrial sites reduced by up to 51%	Hedonic price model
Dale et al. 1999	Resi-dential	Value adjustment for nearby properties to properties farther away after successful rehabilitation of a contaminated site	Hedonic price model
Jackson 2001b	Industrial	Reduced market sales/willingness of banks and investors to finance contaminated sites	Metaanalysis
Jackson 2002	Industrial	Less stigma as remediation progresses; property value recovers from environmental risk-related reductions of 27.8 - 30.5% after completion of rehabilitation	Multiple regression analysis
Longo / Alberini 2005	Industrial	No significant neighbourhood effects	Hedonistic price model
Jackson 2005	Industrial	93.2% of lenders refuse to grant mortgage for contaminated site before remediation, thereafter 65.3% grant a credit, risk assessment of investors is lower than that of banks	Survey
Simons / Winson-Geideman 2005	Resi-dential	Negative valuation effects on proper-ties impacted by leaking underground storage tanks (LUST) from −25-33%.	Contingent valuation
Messer et al. 2006	Resi-dential	Stigma may result in sale prices taking 5 to 10 years to recover after contamination has been cleaned up.	Psychology & hedonic price model
Boyle et al. 2010	Resi-dential	A property-specific contamination incident that is treatable may not have a long-lasting effect on sale prices	Hedonic price model
Simons / Saginor 2010	Industrial	Property losses from 0-40% depending on environmental conditions and proximity to the source (LUST)	Contingent valuation
Shelem et al. (in press)	Resi-dential	Significant neighbourhood effects after the general public became aware of the contamination of a defence fore site	Hedonic price model

[a] Patchin (1994) describes eight case studies, one indicating a stigma effect of 93.7%. In correspondence with Paul Syms he agreed that not all reduction in value could be due to stigma. Therefore, this case study was omitted (cf. Syms 1997, 185).

4 SYNOPSIS OF VALUE-EFFECTING RISKS

A potential buyer or developer of a site (presumably) polluted by previous use faces a number of detrimental conditions. In the literature (Patchin, 1991, Syms, 1997, Bell, 2008, Kerth and Griendt, 2000, Rodewig, 2002, Bell, 2003, Woestmann et al., 2011) a variety of determinants leading to markdowns are found. These can be stylized to fit into four categories representing different risk dimensions that are often related to uncertainties (i.e. the probability and extent of the risk for value reduction cannot be contained):

1. *Risk of liability claims:* Under civil law, private claims for damages may be made on the property owner/purchaser while, under public law, the public may demand measures to be taken for hazard defence. This risk exists regardless of the intended use if there was previous soil or groundwater pollution. It thus establishes a duty to redress for the problem owner even if she has no interest in developing the site. Legally, hazard defence requires precautionary action. Costs will particularly accrue under ordinances for hazard investigation and prevention. At the stage of mere suspected contamination, there is a large-scale uncertainty with regard to the risk of liability claims which lessens as authority and, possibly, private claims become more concrete. After rehabilitation and when private claims have been met, the risk is basically zero. However, sites will often carry a residual uncertainty of subsequent and unexpected claims even after rehabilitation, for example if stricter legislation is suspected (cf. Bond et al., 2001) and that further remediation might be required in the future (Weber et al., 2008). Uncertainties with regard to the risk of liability claims will impair marketability (cf. Slutzky and Frey, 2010).
2. *Investment risks:* The intended use of a site will normally cause extra costs, e.g. for the disposal of polluted but non-hazardous materials and for the excavation of soil for building work. All of them are categorized as *site treatment costs*. There may also be use-related *additional* costs for soil remediation in case of particularly sensitive uses such as playgrounds. *Burdens not under duty of redress* from the viewpoint of hazard defence may still lead to higher and uncertain investment risks if restrictions of use are to be avoided. This risk itself in as much as the uncertainty to quantifying it affects the market value. The expenditure which may be allocated to the planned investment is sometimes referred to as the *literal* investment cost or “investment risk” (a quantity with uncertainty).
3. *Usability risks:* Where remediation costs are out of proportion, authorities have to impose additional precautionary measures and restrictions. Value may be particularly reduced by use restrictions, e.g. for playgrounds, green spaces, civil engineering, etc. While such clearly defined restrictions are not an obstacle for the assessment of value, it is quite difficult (and insecure) to determine uncertain future use restrictions at an early stage of revitalization planning.
4. *Stigma and marketability risks:* Even if all authority requirements for use and private claims are met, properties with a history of contamination will still have a battered image. Potential buyers will be biased against sites which have been polluted by previous use and harbour fears (often without any objective or legal justification) of hidden risks and uncertainties. In business terms, this widespread empirical phenomenon of *stigmatizing* contaminated sites leads to long holding periods and/or higher marketing costs and should therefore be calculated as a hard fact when it comes to appraisal and investment. Stigma in this context is understood to be phobia or fear of negative effects or follow-up costs that can cause a diminution of the market value even after a proper site remediation was completed.

5 THE CONCEPT OF MERCANTILE VALUE REDUCTION

It is crucial for understanding and economically assessing these quantities outlined above that at best they are risks. Although the professional appraiser's measurement of value and impacts to value should be made objectively and should always be based on market data (cf. USPAP AO9), these risks are factors which by potential investors and developers usually can only be determined and sometimes have to be subjectively estimated within upper and lower limits (cost margins) or predict actual costs only in a probability distribution. Stigma as phobia and the uncertainties with regard to these quantities therefore add up and may easily be perceived as extreme if they are not addressed and quantified in a transparent way. The value of sites polluted by earlier use may improve considerably when these uncertainties are restricted through better information (quantification), public rehabilitation contracts and private insurance. Objectifying risks and uncertainties in this respect is a central concern of valuation. Thus, European standards point to the appraiser's duty to consider and report any risks, uncertainties, volatilities and other aspects which come to her knowledge and may affect the value determined (EVS4 6.7.).

In the economic valuation of (previously) contaminated sites the amalgam of these uncertainties will influence market behavior and cause a markdown which hereafter is referred to as *Mercantile Value Reduction* (MVR). The term *mercantile* is derived from the Latin verb *mercārī* meaning to trade, to market, to do business. It is used to emphasize the market based origin of a value reduction (1) usually associated with stigma and (2) arising from uncertainties in assessing risks associated with contamination as perceived by market participants.

In economics terms, MVR is the difference between the market value of an uncontaminated site and that of a site awaiting rehabilitation, less treatment costs and less rehabilitation costs, including an assessment of above mentioned risks, as *estimated by an environmental expert*. It will invariably be greater than the appraised property stigma or risk effect as set in USPAP AO9 (cf. Jackson, 2010) because it makes allowance for uncertain rehabilitation, treatment, marketability costs and usability risks. The effect of MVR on the market value of sites polluted by previous use is illustrated in Figure 1.

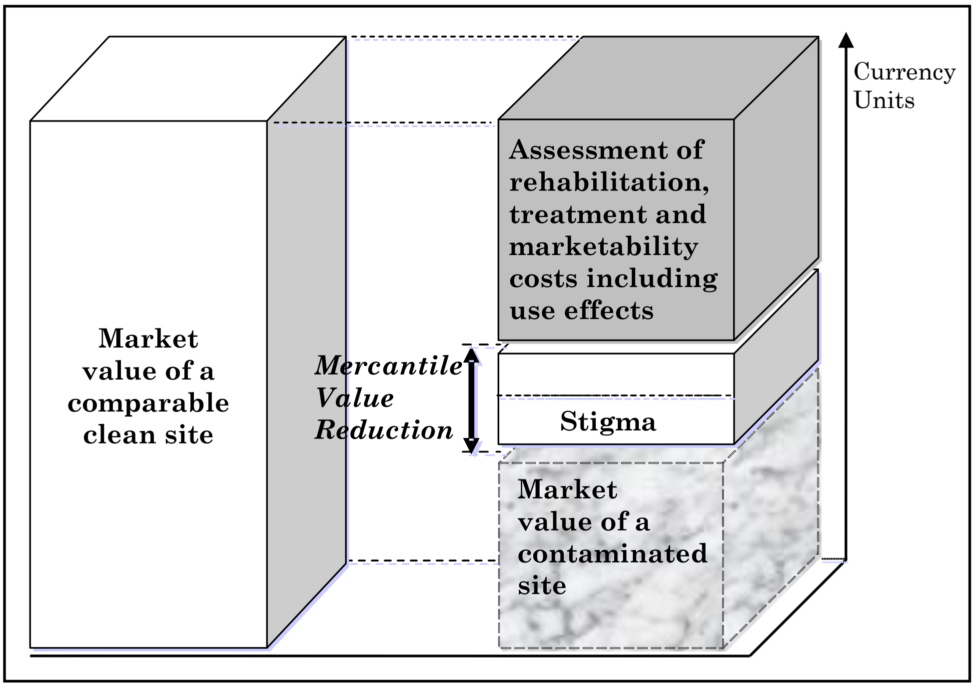

Figure 1. Effect of Mercantile Value Reduction on the market value of contaminated sites.

The amount of MVR depends on the level of information for the assessment of rehabilitation, treatment and marketability costs. It shrinks as this level rises but certainly not goes down to zero as psychological effects of stigma from the history of contamination often persist even after when rehabilitation is completed. In principle, levels of information and experience rise as rehabilitation and reuse proceed so that there is less uncertainty regarding value reduction from undetermined costs. Mercantile value reduction, then, invariably drops over time. Chalmers and Jackson (1996), just like Roddewig (1996), introduced this so-called *life cycle hypothesis*. It claims that risks caused by contamination are greatest prior to rehabilitation, decrease during site treatment and lessen even further after the end of remediation. Dale et al. (1999) empirically confirmed this life cycle hypothesis. All of these authors conceive these time conditions as pricing/explanatory determinants of market value.

Figure 2 shows the elements of MVR as a function of time and respective information levels, with the funnel shape indicating greater certainty in defining risk components. It is assumed that this is the average development for (formerly) polluted properties.

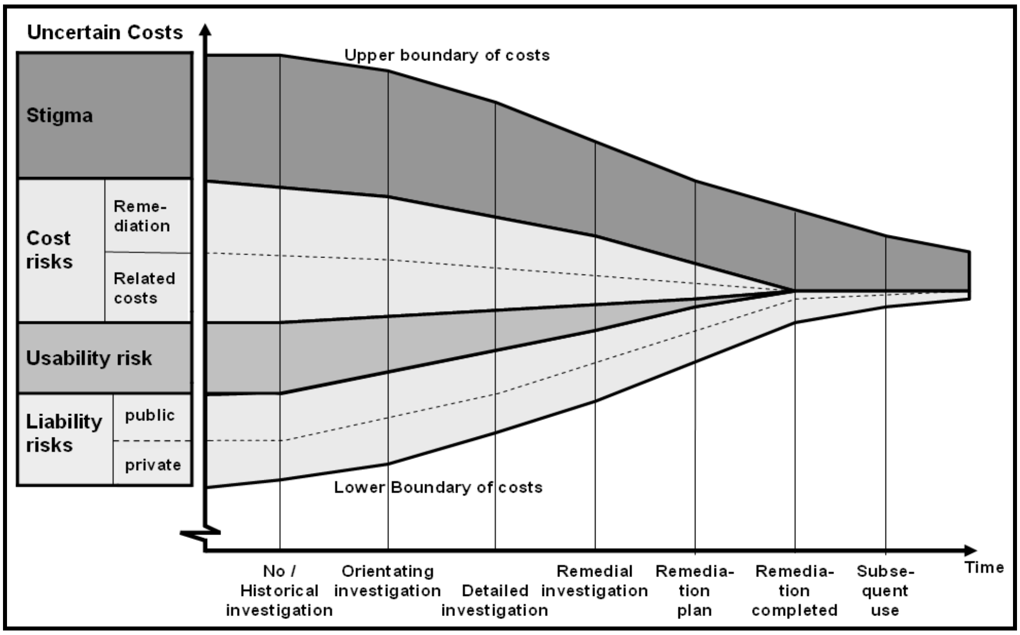

Figure 2. Components and time dependence of Mercantile Value Reduction.

If an approach to assess MVR was to be adopted by appraisers, it would go a long way towards improving transparency, clarifying and demarcating risk structures and (thus) limiting value reductions on contaminated sites. What is missing so far – similar to other appraisal methods proposed in the literature or elsewhere – is a transparent procedure for determining and assessing those uncertainties. This is where the risk assessment method for mercantile value reduction comes in.

6 RISK SCORING METHOD FOR ASSESSING MERCANTILE VALUE REDUCTION

The literature on valuation has not come up with simple methods of quantifying market-related value deductions for risks or stigma effects so far. Most proposals for determining risk-oriented value reductions call for the market resistance to be identified via specific comparative values (cf. Syms and Weber; 2003, Jackson, 2010). Thus, according to Bell (2003), estimated "stigma effects" on market values should be "supported by actual market case studies or data" (ibid. 1510). However, such data is not readily available or cannot be gathered by appraisal experts due to financial or temporal constraints. Moreover, Weber et al. (2008) emphasize that the uniqueness of environmental risk due to site the specific heterogeneous nature of subsurfaces is vulnerable to comparison as an approach to valuation. Caveats need to be considered when using case studies to estimate stigma and its resultant loss in value. The authors note that only assuming that sites have been polluted with the same type of contaminant possessing equivalent risk does justify a sales comparison approach to value, but “the heterogeneity of the soil in the subsurface results in unique problems, so comparisons (comparables) are not valid” (ibid, 14).

The method proposed here combines

(1) the requirement made by Bell, Jackson and others to incorporate market knowledge and data as far as possible,
(2) the concept of expert polls to identify and understand the effect and size of value reductions as applied by Syms (1997) (cf. also Bond and Kennedy, 2000, Kinnard et al., 2002 for examples of expert polling), and
(3) the findings from the literature on the determinants of value diminutions of (previously) polluted sites.

The aim is to provide a practicable and easy-to-use tool which blends general market data/experience and specific property features in determining the particular Mercantile Value Reduction (MVR) of a property being appraised.

In line with Crocoll et al. (2007), Moser (2009) and Syms (2010), the separate determination of a market-related reduction at the end of a conventional appraisal procedure is recommended as best suited for the transparent quantification of risks and uncertainties. This summary reduction is equivalent to MVR and, in appraisal terms, equals the difference between the market value of a non-contaminated site and that of a comparable property awaiting cleanup, less rehabilitation and treatment costs estimated on the basis of good practice taking into account highest and best use. At any time, this comprises the uncertainties that remain even after cleanup and, possibly, during follow-up use (i.e. stigma, marketability and liability uncertainties). The combined valuation of cost uncertainties before, during and from rehabilitation *and* of the marketing of contaminated sites is typical for the concept of *Mercantile Value Reduction*.

This clear definition of the concept is necessary for a uniform, objective and comprehensive approach of value reductions for sites polluted by previous use, and therefore is the first and most important step for the risk assessment method developed here (Figure 3).

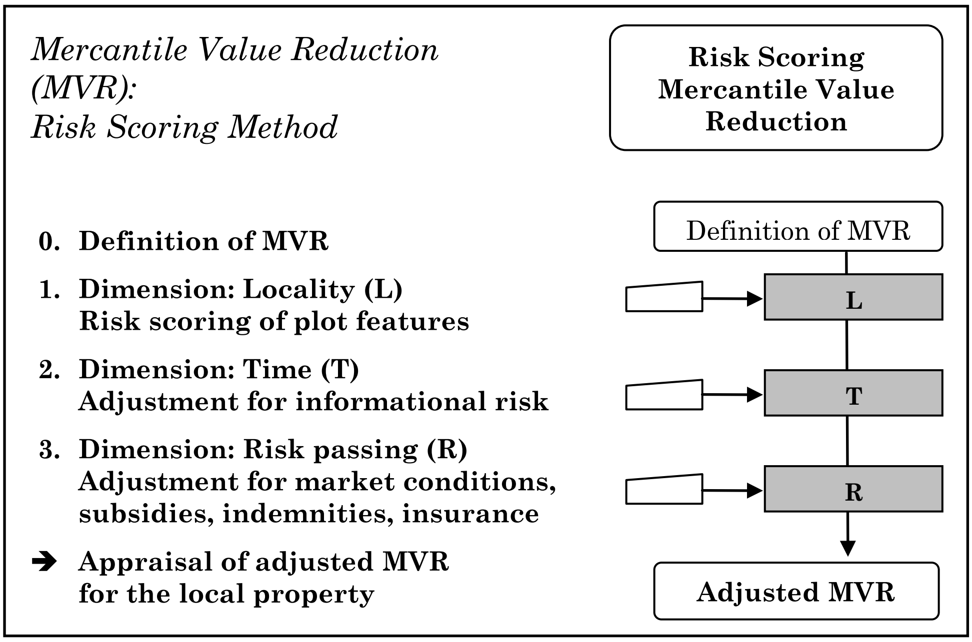

Figure 3. Risk scoring concept to determine a MVR specific to the site being appraised.

Factors which normally affect the amount of value reduction are established from the literature review and a number of technical discussions and workshops. Semi-structured individual interviews addressing the issues filtered out from the literature survey were conducted on a face-to-face basis with eight sworn appraisers active in the valuation of real estate and remediation cost assessment, selected for their proven expertise in these disciplines. In spring 2008, a questionnaire based on the interviews was designed for a major survey among German professional appraisers to review the valuation methods employed in the appraisal of (previously) contaminated sites and to collect the average extent and determinants of the type and scope to establish stigma and market reluctance basic to MVR assessment based on the surveyed professional appraisers' observations of average market transactions of sites actually or previously polluted from earlier use. The poll was pretested in an online survey, readjusted and than mailed to 285 appraisers. It had a rate of return of 32.3% (n=92). In June 2008, the MVR assessment concept was introduced, reviewed and discussed with leading experts from academia and practice in a workshop. Three factors to calculate the (absolute) Mercantile Value Reduction can be summarized as a result:

(I) Local factors → F_L,
(II) Informational factors (time) → F_T,
(III) Risk passing-on factors → F_R.

Equation (1) presents the interrelation of the factors and the respective components, which will be explained in detail.

$$MVR_{abs} = \overbrace{\left(\underbrace{\sum_{l=1}^{13} \left(I_l * m_l * w_{I_l} \right)}_{F_L} \right) * \left(\underbrace{\sum_{t=1}^{2} w_{I_{t_i}} - 1}_{F_T} \right) * \underbrace{w_{I_r}}_{F_R}}^{MVR} * V_{CL} \tag{1}$$

Ad (1) Local Factor → F_L

In the literature review different local determinants were identified which are presumed to have a significant impact for market value diminution. Based on the expert interviews, 13 easily traceable characteristics were compiled defining the value reduction as key determinants due to the particular local character of a site compared to an average diminution level in the limits between 5% and 30% as observed in the literature (e.g. Jackson, 2002, Kleiber et al., 2010) and verified on mean by the polled experts. The analysis yields a risk-related reduction of 12.25% for a contaminated property on average in the point in time of suitable-for-reuse remediation completion. For the 13 detected local property characteristics, different weights m_l reflecting the influence on the overall diminution were assigned in the expert poll (cf. Figure 4) as medians of responses to specify the extent of marketability reduction given the respective characteristics are known or supposed to be true based on the polled professionals' oberservations of previous market transactions (cf. Figure 4).

According to the oberservations of the experts polled, these *local characteristics l* for instance have a small (-), moderate (--) or strong (---) effect on the amount of marketability reduction:

- Visible safeguards such as barriers and fences (-)
- Poor demarcation of (supposed) contamination (-)
- Property listed in an official register of suspected contaminated sites (--)
- Large size of (supposed) contaminated area to total area (>15%) (--)
- Great media attention for contamination risk (---)
- Groundwater contamination is confirmed or very likely (---)

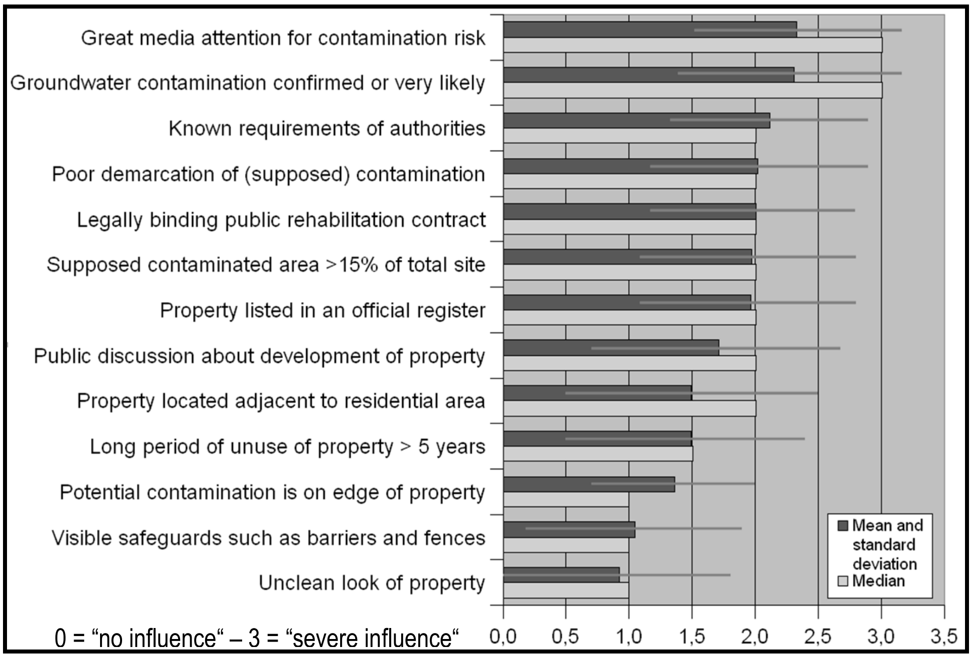

Figure 4: Different weights for local characteristics equalling medians of expert poll.

In a risk scoring approach where an expert appraiser relates local conditions to average conditions prevailing for sites contaminated from earlier use, the sum of these property characteristics results in a proportionate value reduction F_L between 5% and 30%, which is subsequently adjusted by the factors "time" F_T and "risk passing" F_R as indicated in above mentioned equation (1). For F_L, appraiser's input I_l indicates the extent of actual application of each characteristic l for the site to be evaluated. The expert is to give a score between I=1 "not at all / much less than on average" and I=5 "totally true / much more than on average" for each factor that states the actual existence and extent of each determinant on the site to be evaluated; m_l represent median values for characteristics l according to the poll, and w_{ll} are weights to transform the summed up medians into the interval of 5% to 30%.

These characteristics are used to define the particular *local* character of MVR. For example, an intensive local debate on pollution hazards and severe indications for groundwater pollution will considerably increase the risk-related reduction, e.g. from the average of 12.25% (i.e. when I_l=3 for all l, e.g. when there is no particular media attention and no knowledge on the extent of contamination in the groundwater) to 16.60% (if media attention is very high and groundwater damage appears certain). The specific conditions for the model, i.e. the weights w_l and medians m_l for the characteristics, reference values for average conditions (i.e. lower boundary of 5%, average of 12.25% and upper boundary of 30%), etc., can result from the appraiser's expert opinion regarding the conditions on the relevant property market or may be obtained in the case of missing market data, for higher-ranking or as practical aids from market observation or polls of experts such as the one applied here.

Noteworthy, the expert poll is not applied here in a contingent valuation approach for the hypothetical market of the site to be assessed. Contrary, observations by the professional appraisers are used to characterise the market resistance and behaviour with regard to an averagely site remediated suitable-for-reuse based on their experienced proficient and independent observation of market transactions. When local or current market data is missing, this approach to characterise an average diminution level, which is adjusted for the specific local characteristics, is assumed to be applicable and more appropriate than hypothetical studies or market interviews, which can often capture only partial value determining market perceptions (cf. for critique Jackson, 2004b, Wilson 2006).

Ad (2) Informational Factor (Time) → F_T

The local risk of value reduction will decrease as the date of valuation is moved forward in the planning and cleanup process (cf. Chalmers and Roehr, 1993, Jackson, 2009). Over time, more information emerges on liabilities and the cost of rehabilitation, etc. and the MVR goes down as progress is made (stylized funnel shape in Figure 2). In line with Wiltshaw (1998) who categorized the market perception of stigma into pre and post-remediation, the calculation of a correction factor "time" F_T for these influences is divided in the model here for points in time prior and post *ready for use cleanup completion*, as represented by the weights w_{Iti}. This reflects the fact that MVR drops over time t_i (i=1) before site rehabilitation due to increasing availability of detailed information about remediation and rehabilitation costs, and (i=2) after site rehabilitation, when remaining negative impacts diminish.

At a higher level, factors $t_{i=1}$ for assessing this risk as a function of time/information can be gathered from looking at cleanup cost margins at different planning stages. Using data from the Netherlands, in an approximation procedure for estimating lower and upper rehabilitation cost limits Kerth and Griendt (2000) obtain uncertainty factors (with a confidence level of 80%) shown in Table 2. If, for example, the only information available stems from a historical investigation study, actual costs after the cleanup will be between 50 and 200% of the current estimated value in four out of five cases. Risk assessment factors with t being points in time (characterized as information levels and to be stated by the expert as input for the site to be evaluated) before remediation completion can thus be determined so that, for instance, the MVR of an appraisal based on an initial historical investigation will be 1.40 times that obtained after rehabilitation completion (standardized = 1).

Table 2: Informational risk factors

Information level for w_{Iti}	i=1							i=2
	No study	Historical investigation	Orientating investigation	Detailed investigation	Remedial investigation	Remediation Plan	Remediation completed	Points in time for subsequent use
Lower limit	10 %	20 %	50 %	70 %	80 %	85 %	100 %	–
Upper limit	280 %	260 %	200 %	160 %	140 %	130 %	100 %	–
Resulting factor F_T	1.45	1.40	1.25	1.15	1.1	1.08	1.0	$t \rightarrow e^{-0,5t}$

Source: Own presentation with lower and upper limits for i=1 based on Kerth and Griendt (2000), 8f.

Time as a factor has an effect beyond that formal date of suitable-for-use-remediation-completion ($t_{i=2}$). The results of the poll of experts undertaken by the authors show, in line with the international literature (cf. Mundy 1992b, Weber et al., 2008) that an ongoing perception of risks and reduced marketability for contaminated sites, greatly diminishes over time as use of the area continues. According to the survey results, these risks and stigma surrounding such a site disappear almost completely within 10 years – during the first year of use even more than in the 10th year. This decline for factors $t_{i=2}$ is incorporated into the model using an exponential function $I_t \rightarrow e^{-0,5t}$ with I being the input of the expert user and t being the point in time (in years) after suitable-for-use-remediation completion of the site to be analysed. Due to missing data, this curve progression in the model is not based on empirical data. However, reasonable assumptions on the declining shape support the approximation. It is confirmed by the expert interview and the survey result that the function value for the point in time of remediation completion (F_T=1) equals 12.25% on average followed by a downward slope. A *time/information level adjusted local risk* of value reduction can be determined by linking the informational risk to the local MVR.

Ad (3) Risk Passing-on Factor → F_R

However, the actual amount of risk-related reduction will depend on the type and regional location of the property. As Wilson (1996) already points out, allowance has to be made for general market conditions, i.e. cyclical supply and demand fluctuations above or below average, as a variable affecting the actual impact of awareness of previous contamination on the effective market prices of real estate. Also, Patchin (1994) and Simons and Sementelli (1997) find stigma-related value reductions for industrial land, which grow with the substitutability of a property, i.e. depended on the market situation.

The factor "risk" w_{Ir} reflects this market dependency. Risks can be passed on from the sellers to the buyers of a site, thus, reducing the value reduction. The MVR "risk" factor F_R is based on the following theoretical assumption: The extent to which potential buyers lower a price due to perceived uncertainties depends on market dynamics and risk passing possibilities. During a boom, in a booming region or in the case of premium properties, sellers can pass on most of the risks, thus, reducing observed value reductions. In a slump or shrinking region where there is little demand for particular types of property, buyers will have many options to invest in alternative sites and therefore may obtain greater value reductions. Therefore, the amount of a specific market-based reduction depends on the concrete market situation with a factor w_{Ir} equal to zero (acute shortage and great demand in a booming market) to one (big oversupply of similar properties). In a balanced market, the factor should be 0.5 with the risk shared by buyers and sellers. This market adjustment is a result of the expert users input I_r indicating the market condition for the site to be appraised. This statement in particular calls for the expertise of an appraiser in the specific region and for the concrete type of use. Other factors for passing on risks include insurance contracts, public grants or deeds of release whereby some of the cleanup and liability risks are transferred to third parties. They are included in the model at this stage.

The absolute mercantile value reduction → MVR_{abs}

The product of introduced risks factors for location, time and feasibility of passing on risks equals the MVR in percent. This unit-free measure is proportional to V_{CL}, the theoretical comparative land value adjusted for quality of location and state of development. As indicated in equation (1) and shown in the following application example, MVR and V_{CL}, are combined to determine the absolute value reduction for a specific property to be appraised.

7 APPLICATIONS

In order to be useful, Syms (1997) states that a model must replicate realistic considerations and resist testing against case study scenarios of actual transactions: "Any proposed model needs to conform, so far as is possible, to the procedures recommended by the surveying profession, otherwise it is unlikely to be accepted by practitioners" (Syms 1997, 197).

Therefore, the risk scoring and assessment method developed here was applied (1) in different real world case studies and (2) tested separately by independent experts who are active in the marketing of contaminated and conversion sites in a *with-and-without-test* approach.

Application in the case of Krampnitz

To illustrate the application of the MVR methodology, the appraisal of risk effects of the former military site Krampnitz (Germany) is presented. This case study site is located approximately 10 km North of Potsdam in a suburb close to the German capital Berlin (c.f. for this and more detailed site description Schaedler et al., 2011). Krampnitz having an area of approximately 113 ha (280 acres) was used by armoured infantry of Nazi-German and Soviet armed forces until 1991. The operation of petrol stations and a chemical cleaning facility caused immense contamination, in particular by chlorinated solvents such as trichloroethylene (TCE) and tetrachloroethylene (PCE). The site contains both listed historical buildings and economically useless buildings. At present, the site is idle and not used. The adjacent area is characterised by a suburban residential area in the South, two lakes in the East and Southwest, parcels used for agriculture in the West and a nature reserve in the North. The site is aimed at being re-used for commercial and residential purpose.

To assess the impaired market value, a Comparative Land Value V_{CL} is calculated in a residual valuation approach (i.e. the impaired value excluding MVR). As further described in Schaedler et al. (in press), V_{CL} is assessed by deducting from the hypothetical as-if-clean value referring to the specific location quality adjusted market data of comparable uncontaminated sites in the Krampnitz region (1) the site's preparation and development costs, losses due to holding periods, planning and construction of infrastructure and (2) estimated costs for suitable-for-reuse remediation actions and related costs. MVR was applied as follows to assess the impaired market value of Krampnitz by taking into account potential marketability risks and uncertainties regarding the cost estimations as a diminution of V_{CL}. All evaluations were made with regard to the same present effective date of evaluation.

Table 3: Assessment of Local Factor F_L for Krampnitz

Characteristic l	Situation in the Krampnitz case	Input I_l	Mean m_l	Weight w_l in %	$I_l * m_l * w_l$ in %
Poor demarcation of (supposed) contamination	Hot spots of contamination probably known but not distribution	3	-2	0.167	-1.00
(Supposed) Contaminated area > 15% of total site	Contaminated area is ex-pected to be 15% of total area	3	-2	0.167	-1.00
Groundwater contamination is confirmed or very likely	Severe contamination is confirmed	5	-3	0.245	-3.67
Unclean look of property	It is worse than average	4	-1	0.216	-0.86
Visible safeguards such as barriers and fences	Fences only at site boarders – no unusual safeguards	3	-1	0.167	-0.50
Known requirements of authorities	Authorities stated clear remediation requirements	4	-2	0.216	-1.72
Property listed in an official register	Site is listed in public register of contaminated sites	5	-2	0.245	-2.45
Legally binding public rehabilitation contract	No such contracts exist	1	-2	0.204	-0.41
Long period of unuse of property > 5 years.	Property is idle for 15 years, so more than on average but not what is known as worst	4	-1.5	0.216	-1.29
Property located adjacent to a residentially used area.	This is true, but residential area is only small	3	-2	0.167	-1.00
(Potential) contamination is on edge of property	Not directly, but ground-water flow is toward nature reserve North of the site	4	-1	0.216	-0.86
Great media attention for contamination risk	Local media rarely reports on contamination	3	-3	0.167	-1.50
Public discussion about development of property	The economic perspectives of redeveloping the site are discussed regularly	4	-2	0.216	-1.72
Location Factor F_L					-18.00

Firstly, local determinants characterising the site were judged to gauge the Location Factor F_L. Table 3 presents the evaluation of local characteristics l. Each characteristic was rated giving input I_l against the extent that on average is to be expected, i.e. $I_l = 1$ if the condition did not apply at all to the Krampnitz site, via $I_l = 2$ if it did apply but less than in average cases, up to $I_l = 5$ if it applied fully and much more then on average.

Next, the Informational Factor (Time) F_T representing the actual level of available information is gauged. In the case of Krampnitz, different groups of consultants and researchers conducted several historical and orientating investigations. As no detailed investigation had been conducted by the effective date of valuation, according to Table 2, F_T for Krampnitz equals 1.25.

Thirdly, the Risk Passing-on Factor F_R was assessed. In the case of Krampnitz for the planed reuse option and the effective date of valuation, the market condition was appraised by a professional local appraisal expert as "balanced". Therefore, F_R is set 0.5 indicating that the seller and any potential average buyer in an arm's length transaction will share the risk.

Combination of factors F_L, F_T and F_R gives the property specific MVR:

F_L – Local "Mercantile Value Reduction (MVR)":		***- 18.00 %***
F_T – Multiplier for planning phase:	*	**1.25**
F_R – Multiplier for feasibility of passing on risks:	*	**0.50**
MVR – Property-specific MVR:	=	*- 11.25 %*
V_{CL} – Comparative land value		
(as for developed land less clean-up and other development costs)	*	**4,210,000 CU°**
MVR_{abs} – Estimated absolute MVR:	=	***470,000 CU°***

°CU = Currency Unit

Applications by independent experts

The MVR assessment was applied in a broader case study approach on a sample of properties in Germany in a *with-and-without-test* approach. This type of testing is common in natural sciences and considered a proper conceptual measure of indirect impacts (Litman, 1995). Starting without knowledge of the MVR method, experts were asked to list at least five properties of their choice from their own practice and to rank them according to their perceived marketability. Afterwards, the experts were introduced to the MVR concept and asked to assess the mercantile value reductions accordingly.

An exemplary case study with six sites evaluated by four experts with different professional backgrounds is illustrated in Table 4, introducing the case study sites in the German state of Thuringia, and Table 5, showing the initial ranking and MVR assessment results of the experts.

Table 4: Case study sites in Thuringia, Germany

Case Site	Area in hectares	Last use	Current use	Proposed use
A – ROTASYM, Pößneck	3.60	trade / industry	none / demolition	trade
B – WGT-Site Forst, Jena	34.10	military / conversion	none / vacancy / demolition	ecological compen-sation area for highway extension
C – WGT-Site Fuel Depot, Jena	1.10	trade	underused trade	trade
D – Weimar-Factory, Bad Lobenstein	0.63	trade / industry	vacancy / demolition	trade
E – Freight Station, Sonneberg	7.00	rail freight station	95 % vacancy / temporary use of engine-house	mixed use area / temporary use as an urban park
F – Tar Basins, Sättelstädt	1.60	tar basins / storage area	partially storage area	renaturation

Table 5: Thuringian case study ranking and MVR assessment by experts

	Case Site	A	B	C	D	E	F	$\Sigma\Delta_R$	$\rho_{R,R_{MVR}}$ (σ)
Expert 1 (ap-praiser)	R	3	5	1	4	2	6		
	MVR	16.0%	17.4%	1.3%	17.9%	5.7%	17.8%		0.829**
	R_{MVR}	3	5	1	6	2	4		(0.042)
	Δ_R	0	0	0	2	0	2	4	
Expert 2 (de-veloper)	R	1	6	4	5	3	2		
	MVR	13.1%	16.0%	15.7%	17.6%	8.6%	4.0%		0.771*
	R_{MVR}	3	5	4	6	2	1		(0.072)
	Δ_R	2	1	0	1	1	1	6	
Expert 3 (en-viron-mental expert)	R	1	6	5	3	2	4		
	MVR	11.4%	12.6%	16.5%	16.3%	8.6%	11.6%		0.657
	R_{MVR}	2	4	6	5	1	3		(0.156)
	Δ_R	1	2	1	2	1	1	8	
Expert 4 (estate agent)	R	2	5	3	4	1	6		
	MVR	14.0%	20.2%	13.4%	18.6%	12.3%	22.5%		0.943***
	R_{MVR}	3	5	2	4	1	6		(0.005)
	Δ_R	1	0	1	0	0	0	2	
Avarage of Experts	R	1.75	5.5	3.25	4	2	4.5		
	MVR	13.6%	16.6%	11.7%	17.6%	8.8%	14.0%		0.782*
	R_{MVR}	2.75	4.75	3.25	5.25	1.5	3.5		(0.066)
	Δ_R	1	0.75	0	1.25	0.5	1	4.5	

R = Rank, MVR = Mercantile Value Reduction, R_{MVR} = Rank MVR, $\Delta_R = |R - R_{MVR}|$
$\Sigma\Delta_R$ = Sum of Δ_R per Expert, $\rho_{R,R_{MVR}}$ = Correlation Coefficient (Pearson) of R and R_{MVR}
*σ = Significance with * < 10%, ** < 5%, *** < 1% probability of error*

In Table 5, the initial rankings *R* for each expert from a first individual estimation of the sites A to F and the *MVR* assessment results in percent are shown. Additionally, a ranking R_{MVR} derived from MVR results are presented and for information the differences between the two rankings. As can be seen, initial and MVR rankings follow a similar pattern which indicates, that both are mirroring the same effects with regard to the marketability of the contaminated sites. Moreover, measuring the statistical dependence between these two variables with Spearman's rank correlation coefficients $\rho_{R,RMVR}$, indicates a strong relationship supported by high significance levels (σ). Except for the environmental expert, all coefficients are significant, most so for the appraiser (probability of error < 5%) and the estate agent (< 1%). Finally, calculating the average of the experts' estimates and taking the mean of their MVR assessments again confirms a significant and strong relationship between the knowledge of the local experts for the validated case study sites and the general MVR assessment.

Results support a high level of validity for the MVR assessment method, with marketability rankings in initial appraisals being in line with MVR valuations by risk scoring. Therefore, it can be expected, that the MVR method in general allows assessing the value diminution of a contaminated site.

The concept of MVR has been introduced to different authorities, state development companies, independent appraisers and experts in contaminated site valuation. It has been found that the proposed factors are highly practicable because they are valuation-relevant and readily accessible with minimal information gathering efforts. The MVR technique was seen as generally suitable to objectify risks leading to stigma and uncertainties of market participants. It was considered a valuable contribution to make sales of derelict land more attractive for potential investors by authorities.

8 CONCLUSION

A review of success factors for derelict site revitalization projects has identified the real estate market as essential for the reuse of land polluted by earlier use. A high demand for land will increase its value, with the general price increase on the one hand suggesting potential reuse and, on the other, improving returns on investment into revitalization projects (Argus and Opper, 2008). With its more transparent assessment of contamination-related risks, the method proposed in this paper also helps to raise the awareness for cleanup projects and reduce land consumption.

Risk scoring and the algorithm presented here are *one* way of identifying market-perceived risks for sites polluted by earlier use in a transparent and comprehensible manner. Quantities such as location, time and feasibility of passing on risks can be combined in an assessment approach to determine the absolute value reduction for a specific property to be appraised. Results help appraisers, international investors and portfolio managers to deepen their understanding of valuation of risks associated with (previously) contaminated land.

Alternative approaches can be imagined and may be practicable. The scoring method proposed here appears to be particularly suitable because it is widespread in property appraisal (excluding contaminated sites) (e.g. TEGoVA, 2003). To achieve a similar amount of reliability, it should be given more concrete basis and be tested against the background of empirical and market studies. From the procedures proposed here we generally expect better transparency, harmonization and objective results in the valuation of contaminated sites, which will reduce perceived uncertainties.

However, whether such an effect can be achieved will not be seen until these procedures have been integrated into the practice of appraisal. Until then, a large number of political and legal hurdles remain to be cleared.

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REFERENCES

Adair, A., Lim, L.C., Crosby, N. and Watkins, C. (2001) An emerging European valuation research agenda: Evidence from the European Real Estate Society and the RICS Cutting Edge Conferences, paper presented at TEGoVA Conference 1 November 2001, Berlin. Available at: http://www.tegova .org/data/bin/4912f81fc63d8_esreport.pdf [accessed 12 April 2010]

Adams, C.D., Baum, A.E. and MacGregor, B.D. (1985) The influence of valuation practices upon the price of vacant inner city land, *Journal of Property Research*, 2(3), pp. 157–173.

Appraisal Foundation (Ed.) (2008) *Uniform Standards of Professional Appraisal Practice (2008-2009 Edition USPAP + Guidance)*, The Appraisal Foundation, Washington, DC.

Appraisal Institute (Ed.) (2008) *The Appraisal of Real Estate*, 13th edition, The Appraisal Institute, Chicago, IL.

Bartke, S. (2010) Appraisal of uncertainties in contaminated land market value assessment, Chemicals in the Environment Conference, Leipzig, Germany, 23 March 2010. Available at: http://www.ufz .de/data/Bartke%20CITE%20201013385.pdf [accessed 30 July 2010]

Beattie, R. (1991) City Grant, *Journal of Property Finance*, 1(4), pp. 588–592.

Bell, R. (2003) Valuation of contaminated property, *BNA's Environmental Due Diligence Guide*, No. 133 3-03, §111 pp. 1501–1510.

Bell, R. (2008) *Real estate damages: Applied economics and detrimental conditions*, 2nd ed., The Appraisal Institute, Chicago, IL.

Bond, S.G., Kennedy, P.J. (2000) The valuation of contaminated land – Methods adopted in the UK and NZ, *Journal of Property Investment & Finance*, 18(2), pp. 254–271.

Bond, S.G., Kinnard Jr., W., Kennedy, P.J. and Worzala, E.M. (2001) An internatio-nal perspective on incorporating risk in the valuation of contaminated land, *The Appraisal Journal*, 69(3), pp. 258–265.

Boyle, K.J., Kuminoff, N.V., Zhang, C., Devanney, M. and Bell, K.P. (2010), Does a property-specific environmental health risk create a "neighborhood" housing price stigma? Arsenic in private well water, *Water Resources Research*, 46, W 03507, 10p, doi: 10.1029/2009WR008074.

Chalmers, J.A. and Roehr, S.A. (1993) Issues in the valuation of contaminated properties, *The Appraisal Journal*, 61(1), pp. 28–40.

Chalmers, J.A. and Jackson, T.O. (1996) Risk factors in the appraisal of contaminated properties, *The Appraisal Journal*, 64(1), pp. 44–58.

Chan, N. (2009) Reassessing the valuation of contaminated land in Australia, *Pacific Rim Property Research Journal,* 15(2), pp. 166–181.

Crocoll, R., Lehmann, J., Stegmüller, V. and Schroth, T. (2007) Altlasten im Grund-stücksverkehr: Wertermittlung kontami-nierter Flächen [Brownfields and the property market: Valuation of contami-nated sites], *wlb (Supplement Terra-Tech)*, 51(10), pp. TT6–TT9. (In German)

Dale, L., Murdoch, J.C., Thayer, M.A. and Waddell, P.A. (1999) Do property values re-bound from environmental stigmas? Evidence from Dallas, *Land Economics*, 75(2), pp. 311–326.

Dasgupta, S. and E.K.L. Tam (2009) A Comprehensive Review of Existing Classification Systems of Brownfield Sites, *Environmental Practice,* 11(4), pp. 285–300.

Dotzour, M. (1997) Groundwater contami-nation and residual property values, *The Appraisal Journal*, 65(3), pp. 279–285.

Frey, J. and Roddewig, R.J. (2006) Testing the reliability of continguent valuation in the real estate marketplace, *The Appraisal Journal*, 74(3), pp. 267–280.

Gamble, H.B. and Downing, R.H. (1982) Effects of nuclear power plants on residential property values, *Journal of Regional Science*, 22(4), pp. 457–478.

Greenberg, M. and Huges, J. (1993) Impact of hazardous waste sitse on property value and land-use: Tax Assessors' Appraisal, *The Appraisal Journal*, 61(1), pp. 42–51.

Großmann, J., Hilse, H. and Lauerwald, U. (2001) Wertermittlung altlastenbehafte-ter Grundstücke in der Praxis [Valuation of contaminated land in practice], *TerraTech*, 10(4), 41–46. (In German)

Guntermann, K.L. (1995) Sanitary landfills, stigma and industrial land values, *Journal of Real Estate Research*, 10(5), pp. 531–542.

Hilse, H. and Bischoff, B. (2005) Konsequen-zen bei der Wertermittlung belasteter Grundstücke als wichtiges Element der Flächenentwicklung [Consequences for the valuation of contaminated land as a major component of land development], in ITVA and AAV (Eds.) *Altlastensym-posium 2005* [Symposium on contamina-ted sites], ITVA, pp. 81–93. (In German)

Hurd, B.H. (2002) Valuing superfund site cleanup: Evidence of recovering stigmatized property values, *The Appraisal Journal*, 70(4), pp. 426–437.

IVSC = International Valuation Standards Council (Ed.) (2007) *International Valuation Standards*, 8th edition, N.P., ISBN 978-0922154944.

Jackson, T.O. (2001a) The effects of environmental contamination on real estate: A literature review, *Journal of Real Estate Literature*, 9(2), pp. 93–116.

Jackson, T.O. (2001b) The effect of previous environmental contamination on industrial real estate prices, *The Appraisal Journal*, 69(2), pp. 200–210.

Jackson, T.O. (2002) Environmental contamination and industrial real estate prices, *Journal of Real Estate Research*, 23(1/2), pp. 179–199.

Jackson, T.O. (2003a) Appraisal standards and contaminated property valuation, *The Appraisal Journal*, 71(2), pp. 127–133.

Jackson, T.O. (2003b) Methods and techniques for contaminated property valuation, *The Appraisal Journal*, 71(4), pp. 311–320.

Jackson, T.O. (2004a) Case studies analysis: Environmental stigma and monitored natural attenuation, *The Appraisal Journal*, 72(2), pp. 111–118.

Jackson, T.O. (2004b) Surveys, market interviews and environmental stigma, *The Appraisal Journal*, 72(4), pp. 300–310.

Jackson, T.O. (2005) Groundwater contamination and real estate investment risk, *Journal of Real Estate Practice and Education*, 8(1), pp. 115–131.

Jackson, T.O. (2010) Real property valuation issues in environmental class actions, *The Appraisal Journal*, 78(2), pp. 141–149.

Kerth, M. and van de Griendt, B. (2000) Monetäre Bewertung des »Altlasten-risikos« [Monetary assessment of »brownfield risks«]. In Franzius, V., Wolf, K. and Brandt, E. (eds.) *Handbuch der Altlastensanierung – Loseblatt-sammlung* [Compendium remediation of brownfield - loose-leaf collection], 22. supplemental set, 2nd ed., 11232, C. F. Müller, Heidelberg. (In German)

Kinnard, W.N., Worzala, E.M., Bond, S.G. and Kennedy, P.J. (2002) "Comparative studies of United States, United King-dom and New Zealand appraisal prac-tice: valuing contaminated comercial real estate", in Wang, K. and Wolverton, M.L. (eds) *Real Estate Valuation Theory*, Klu-wer Academic Publishers, Boston, MA.

Kleiber, W., Simon, J., Fischer, R. and Schröter, K. (2010) *Verkehrswertermitt-lung von Grundstücken* [Market valuation of land], 6th ed., Bundesanzeiger, Cologne. (In German)

Kohlhase, J.E. (1991) The impact of toxic waste sites on housing values, *Journal of Urban Economics*, 30, pp. 1–26.

Lentz, G.H. and Tse, K.S.M. (1995) An Option Pricing Approach to the valuation of real estate conataminated with hazardous materials, *Journal of Real Estate Finance and Economics*, 10(2), pp. 121–144.

Litman, Todd (1995) Land use impact costs of transportation, *World Transport Policy and Practice*, 1(4), pp. 9–16.

Longo, A. and Alberini, A. (2005) What are the effects of contamination risks on commercial and industrial properties? Evidence from Baltimore, Maryland, FEEM-Working Paper No. 111.2005,: Fondazione Eni Enrico Mattei, Milan.

McClelland, G.H., Schulze, W.D. and Hurd, B.H. (1990) The effect of risk beliefs on property values: A case study of a hazardous waste site, *Risk Analysis*, 10(4), pp. 485–497.

McLean, D. and Mundy, B. (1998a) The addition of contingent valuation and conjoint analysis to the required body of knowledge for the estimation of environmental damages, *Journal of Real Estate Practice and Education*, 1(1), pp. 1–19.

McLean, D. and Mundy, B. (1998b) Using the contingent vaslue approach for natural resource and environmental damage, *The Appraisal Journal*, 66(3), pp. 290–297.

Messer, K.D., Schulze, W.D., Hackett, K.F., Cameron, T.A. and McClelland, G.H. (2006) Can Stigma Explain Large Property Value Losses? The Psychology and Economics of Superfund, *Environmental and Resource Economics*, 33(3), 299–324.

Moser, G. (2009) Bewertung und Verwertung kontaminierter Industrie- und Gewerbe-liegenschaften [Valuation and utilisation of contaminated industrial and commercial real estated], Master thesis, Donau Universität Krems. (In German)

Mundy, B., (1992a) Stigma and value, *The Appraisal Journal*, 60(1), pp. 7–13.

Mundy, B., (1992b) The impact of hazardous materials on Property Value, *The Appraisal Journal*, 60(2), pp. 155–162.

Norrman, J. (2001) Decision Analysis under Risk and Uncertainty at Contaminated Sites – A literature review, Swedish Geotechnical Institute, *SGI Varia* 501, SGI, Linköping, ISSN: 1100-6692.

NRC – National Research Concil (2005) *Contaminants in the subsurface: Source zone assessment and remediation*, The National Academies Press, Washington, D.C., ISBN: 0 309 09447 X.

Page, G.W. and Rabinowitz, H. (1993) Groundwater contamination: Its effects on property values and cities, *Journal of the American Planning Association*, 59(4), pp. 473–481.

Patchin, P.J. (1988) Valuation of contaminated properties, *The Appraisal Journal*, 56(1), pp. 7–16.

Patchin, P.J. (1991) Contaminated properties – stigma revisited, *The Appraisal Journal*, 59(2), pp. 167–172.

Patchin, P.J. (1994) Contaminated properties and the sales comparison approach, *The Appraisal Journal*, 62(3), pp. 402–409.

Reichert, A.K., Small, M. and Mohanty, S. (1992) The impact of landfills on residential property values, *Journal of Real Estate Research*, 7(3), pp. 297–314.

Richards, T.O. (1997) Is it worth the risk? The impact of environmental risk on property investment valuation, Research Report 1997/1, College of Estate Management, Reading.

RICS (2008) *RICS Valuations Standards*, 6th ed., RICS Books, Coventry, UK.

Roddewig, R. (1996) Stigma, environmental risk and property value: 10 critical inquiries, *The Appraisal Journal*, 64(4), pp. 375–387.

Schaedler, S., Morio, M., Bartke, S. and Finkel, M. (in press): Integrated planning and spatial evaluation of megasite remediation and reuse options, *Journal of Contaminant Hydrology*, doi:10.1016/j.jconhyd.2011.03.003.

Schaedler, S., Morio, M., Bartke, s., Rohr-Zänker, R. and Finkel, M. (2011) Designing sustainable and economically attractive brownfield revitalization options using an integrated assessment model, *Journal of Environmental Management,* 92(3), 827–837.

Sheard, E. M. (1992) Valuation of contaminated land: Current theory and practice, *Journal of Property Valuation and Investment*, 11(1), pp. 17–27.

Shelema, I., Laveeb, D. and Becker, N. (in press) Contamination by the Israeli military industry and its impact on apartment sale prices in an adjacent Tel Aviv neighborhood: a hedonic pricing model study, *International Journal of Urban Sustainable Development*, doi: 10.1080/19463138.2011.552942.

Siemens, H. (2003) Stigma of contaminated land: Difficult to tackle, *The Appraisal Journal*, 71(2), pp. 121–126.

Simons, A.R. and Winson-Geideman, K. (2005) Determining market perceptions on contamination of residential property buyers using contingent valuation surveys, *Journal of Real Estate Research*, 27(2), pp. 193–220.

Simons, R.A. and Saginor, J. (2010) Determining off-site damages to non-residential property from leaking under-ground storage tanks using Contingent Valuation analysis, *International Real Estate Review*, 13(2), pp. 134–156.

Simons, R.A. and Sementelli, A. (2006) *When bad things happen to good property*, Environmental Law Institute, Washington, DC.

Simons, R.A. and Sementelli, A. (1997) Liquidity loss and delayed transactions with leaking underground storage tanks, *The Appraisal Journal*, 65(3), pp. 255–260.

Slovic, P., Layman, M., Kraus, N., Flynn, J., Chalmers and J., Gesell, G. (1991) Perceived risk, Stigma, and potential economic impacts of a high-level nuclear waste repository in Nevada, *Risk Analysis*, 11(4), pp. 683–696.

Slutzky, D. and Frey, A.J. (2010) Brownfields uncertainty: A proposal to reform superfund, *Cityscape: A Journal of Policy Development and Research* 12(3), pp. 85–100.

Syms, P.M. (1997) *Contaminated land: The practice and economics of redevelopment*, Blackwell Science Limited, Oxford.

Syms, P. (2010) *Land, Development and Design*, 2nd ed., Wiley-Blackwell, Chichester.

Syms, P.M. and Weber, B.R. (2003) International approaches to the valuetion of land and property affected by contamination. RICS Foundation Research Review Series August 2003, RICS Foundation, London.

TEGoVA (Ed.) (2009). *European Valuation Standards 2009*, 6th edition. ISBN 978-90-9024138-8.

TEGoVA (Ed.) (2003) *European property and market rating: A valuer's guide*, The European Group of Valuers' Associations, London.

Thayer, M., Albers, H. and Rahmatian, M. (1992) The benefits of reducing exposure to waste disposal sites: A hedonic housing value approach. *Journal of Real Estate Research*, 7(3), pp. 265–282.

Tonin, S. (2006) What is the value of brownfields? A review of possible approaches. In Alberini, A., Rosato P. and Turvani, M. (eds.) *Valuing complex Natural Resource Systems: The Case of the Lagoon of Venice,* Edward Elgar Publishing, Cheltenham, UK and Northampton, Mass.

Wang, Q, Hipel, K.W. and Kilgour, D.M. (2009) Fuzzy Real Options in Brownfield Redevelopment Evaluation, *Journal of Applied Mathematics and Decision Sciences,* 2009, pp. 1–17, doi:10.1155/2009/817137.

Weber, B.R. (1997) The valuation of contaminated land, *Journal of Real Estate Research*, 14(3), pp. 379–398.

Weber, B.R., Adair, A. and McGreal, S. (2008) Solutions to the five key brownfield valuation problems, *Journal of Property Investment & Finance,* 26(1), pp. 8–37.

Woestmann, U., Kiel, M. and Pietras, C.-P. (2011) Ermittlung der Verkehrswerte von kontaminierten Grundstücken im Treuhandnachfolgebereich nach der neu-en Immobilienwertermittlungsverord-nung [Determination of the market value of contaminated areas in successsion of the German Treuhandanstalt according to the new German ordinance on the valuation of real estate], *Altlastenspek-trum,* 20(2), pp. 62–71. (In German)

Wilson, A.R. (2006) Contigent valuation: Not an appropriate valuation tool, *The Appraisal Journal*, 74(1), pp. 53–61.

Wilson, A.R. (1996) Emerging approaches to impaired property valuation, *The Appraisal Journal*, 64(2), pp. 155–170.

Wiltshaw, D.G. (1998) Stigma, perception and the remediation of contaminated land, *Journal of Property Research*, 15(4), pp. 285–303.